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Reviews on Predicting Type 2 Diabetes and use of AI

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ABSTRACT

The rising incidence of Type 2 diabetes is a major public health problem that needs new approaches for earlier identification and intervention. Beyond acknowledging the obvious harm, traditional diagnostic methods detect the disease after such a significant metabolic shift has taken place; as a result, there is a crucial need for innovative predictive tools. We have data up to mid of 2023 for training in ML algorithms which can identify complex patterns and risk factors in large datasets, including electronic health records and lifestyle information, enabling early identification of at-risk individuals. These range from classic algorithms, such as logistic regression, to modern deep learning models. Yet, the use of AI in healthcare is not without its challenges, such as issues with data privacy and possible bias in AI models. Overcoming these challenges is essential to leverage the full capabilities of AI in diabetes prediction and to deliver equitable health benefits. This paper discusses the role of ML and AI in predicting Type 2 diabetes, the techniques employed, and the ethical considerations that must be addressed to effectively implement these technologies in clinical practice.

Keywords: Type 2 Diabetes, Machine Learning, Artificial Intelligence.**Introduction**

I. Introduction

Type 2 diabetes is a chronic metabolic disorder that affects millions of people globally, contributing to severe complications such as cardiovascular disease, kidney failure, and neuropathy. The increasing prevalence of Type 2 diabetes, driven by factors like sedentary lifestyles, poor dietary habits, and rising obesity rates, poses a significant public health challenge. Early detection and prevention are crucial in managing this disease, but traditional diagnostic methods often rely on clinical symptoms that appear after significant damage has already occurred. As a result, there is a growing need for more advanced, predictive tools to identify individuals at risk of developing diabetes before symptoms manifest. This is where machine learning (ML) and artificial intelligence (AI) can play a transformative role. Recent advancements in machine learning and AI have opened new avenues for predicting complex medical conditions, including Type 2 diabetes, with unprecedented accuracy. Through analyzing large datasets from electronic health records (EHRs), wearable devices, and lifestyle assessments, AI can identify subtle patterns and risk factors that may go unnoticed by traditional methods. These predictive models have the potential to assess a patient’s risk of developing diabetes years before it would be clinically diagnosed, allowing for early interventions that can significantly improve patient outcomes. Machine learning algorithms can learn from diverse features such as age, body mass index (BMI), family history, blood pressure, and glucose levels, developing a risk profile for each individual. A wide range of machine learning techniques are being explored for diabetes prediction, from simple logistic regression models to more complex deep learning networks. Traditional algorithms such as decision trees, support vector machines (SVMs), and random forests have shown considerable promise in handling the structured clinical data often used for these tasks. Meanwhile, deep learning models, particularly those using neural networks, are being applied to integrate multiple data types such as imaging data or continuous glucose monitoring data providing even more comprehensive predictive insights. Advanced interpretability techniques, such as SHAP and LIME, are also helping clinicians understand how AI models make predictions, fostering trust in these systems [1-4].

II. Reviews

Dagliati et al. (2018) explored the application of machine learning within the EU-funded MOSAIC project to develop predictive models for type 2 diabetes complications. Using electronic health records from nearly 1,000 patients, the study implemented a data mining pipeline involving clinical profiling, predictive modelling, and validation. Logistic Regression with stepwise feature selection was employed to predict retinopathy, neuropathy, or nephropathy at 3, 5, and 7 years from hospital visits. Key variables included age, BMI, and HbA1c. The models achieved up to 83.8% accuracy, tailoring predictions for different complications and time scenarios, making them practical for clinical integration.

Sarwar et al. (2018) investigated the use of six machine learning algorithms for predictive analytics in healthcare, specifically for diabetes prediction. By utilizing a dataset of patient medical records, the study aimed to compare the performance of algorithms like Support Vector Machines and Decision Trees. The focus was on identifying the most accurate and efficient algorithm for early diabetes detection. The findings provided insights into the capabilities of machine learning to support healthcare practitioners in making timely, data-driven decisions for patient care, emphasizing the potential of predictive analytics in improving diabetes diagnosis and management.

Padhy et al. (2019) discussed the potential of artificial intelligence in addressing diabetic retinopathy, a leading cause of vision loss. AI's ability to perform pattern recognition was highlighted as a key asset for early screening and diagnosis. The study emphasized the reduction in dependency on human resources for screening and treatment. It underscored the promise of AI in handling large-scale screening and ensuring timely interventions. Additionally, the review pointed to its application in other retinal disorders, offering a broad perspective on AI's transformative impact in ophthalmology.

Ting et al. (2019) focused on the application of deep learning (DL) in ophthalmology, particularly in detecting diabetic retinopathy, macular degeneration, and glaucoma. DL models demonstrated strong classification performance using ocular images like fundus photographs and OCT. The study also explored the potential of DL integration with telemedicine for community-based screening. However, challenges such as algorithm explainability, medico-legal concerns, and user acceptance were noted. The review highlighted DL's potential to revolutionize ophthalmic practice while addressing the hurdles in clinical deployment and patient adoption.

Ellahham (2020) explored the transformative role of artificial intelligence in diabetes management, emphasizing its application in predictive models, self-management tools, and clinical decision support systems. Digital therapeutics and AI-enabled remote monitoring were highlighted as key advancements in glycemic control and patient engagement. The study stressed the potential of AI to transition from traditional management strategies to precision care. Enhanced glycemic outcomes and optimized resource utilization were presented as significant benefits, showcasing how AI could reshape diabetes care through targeted, data-driven interventions.

Wadhwa & Babber (2020) analysed correlations between health parameters like BMI, glucose levels, and blood pressure with diabetes using multimodal patient data. Python-based analytics predicted diabetes effectively, identifying key differences in health metrics between diabetic and non-diabetic individuals.

For example, diabetic patients exhibited higher blood pressure and glucose levels. The findings illustrated how data analytics could uncover critical health patterns, providing actionable insights for early diabetes detection and contributing to improved patient care strategies.

Gautier et al. (2021) examined the potential of artificial intelligence in diabetes care, focusing on disease understanding, diagnosis, and treatment improvement. The authors discussed AI's ability to integrate diverse data sources and powerful computational methods, emphasizing its applications in identifying risk factors and tracking disease progression. The study outlined AI's capacity to enhance personalized treatment strategies and improve outcomes. Challenges in data integration and algorithm development were noted, but the overall assessment showcased AI's transformative potential in revolutionizing healthcare for diabetes patients.

Gong et al. (2021) utilized artificial intelligence and machine learning to identify potential inhibitors for DPP4, a key enzyme in diabetes regulation. By combining regression models, QSAR techniques, and molecular dynamics simulations, the authors identified compound 2007_4105 as a potent inhibitor. Traditional Chinese Medicine Database was used for screening, and AI methods outperformed conventional QSAR approaches. This research highlighted the integration of AI in drug discovery, showcasing its ability to identify effective treatments for diabetes with high accuracy and efficiency.

Chaki et al. (2022) provided a comprehensive analysis of machine learning and AI applications in diabetes detection, diagnosis, and self-management. It categorized methodologies such as dataset preprocessing, feature extraction, and ML-based classification. The study underscored the advantages of automation over manual methods, presenting AI as a valuable tool for early diagnosis and personalized care. The authors also highlighted research gaps, listing challenges and areas for improvement, making the review a significant resource for scientists in diabetes care and management.

Ismail et al. (2022) conducted an objective comparison of 35 machine learning algorithms for type 2 diabetes prediction using three real-life datasets. By employing a unified setup and standardized evaluation metrics, the study assessed algorithms based on accuracy, F-measure, and execution time. The findings identified high-performing models and highlighted the impact of feature selection techniques on predictive accuracy. This comparative analysis offered valuable insights for researchers aiming to select optimal algorithms for diabetes risk prediction and prevention planning.

Vehi et al. (2022) explored AI-based decision support systems designed to manage diabetes by maintaining glycemic levels within the normoglycemic range. These systems provided personalized recommendations for patients and supported clinicians in diagnosing and managing diabetes-related complications. The research highlighted the systems' ability to predict adverse glycemic events, offering proactive measures to prevent complications. The study emphasized AI's role in enhancing patient outcomes and assisting healthcare professionals in making data-driven clinical decisions.

Jacobs et al. (2023) provided guidelines for applying machine learning in diabetes research, emphasizing best practices for algorithm development, dataset utilization, and performance evaluation. The study introduced an open-source library for feature calculations and a framework for data specification. The findings highlighted the importance of clinical accuracy, explainability, and personalization in ML applications. These guidelines aimed to standardize methods, improve algorithm reliability, and enhance the translatability of machine learning advancements in diabetes care.

Khaleel & Al-Bakry (2023) developed a model for diabetes prediction using the Pima Indian Diabetes Dataset, comparing Logistic Regression (LR), Naïve Bayes (NB), and K-Nearest Neighbour (KNN) algorithms. LR achieved the highest prediction accuracy of 94%, outperforming NB and KNN. The research demonstrated the effectiveness of ML algorithms in early diabetes detection and emphasized LR's superior performance. The findings provided insights into how machine learning could enhance precision and reliability in predicting diabetes onset.

III. Global Health Impact of Type 2 Diabetes

Type 2 diabetes represents a major global health crisis, with more than 460 million people worldwide affected and this number showing no signs of abating. Commonly referred to as a chronic metabolic disorder, it is the condition in which the body can no longer be able to use insulin properly, causing sugar levels in blood to rise. The condition not only reduces quality of life but also greatly raises the risk of serious complications including cardiovascular disease, stroke, kidney failure and nerve damage (neuropathy). The complications from these diseases lead to disability, shortened lifespans and a significant burden on healthcare systems. Notably, this comes with a significantly high number of Type 2 diabetes related deaths, as cardiovascular diseases are the number one responsible for the death of a Type 2 individual, where cardiovascular diseases can be noticed as a major contributor to diabetes related death. Low- and middle-income countries are disproportionately affected by the disease; healthcare resources are often limited, and awareness of prevention and management remains low. Increasingly unhealthy lifestyle practices, including poor nutrition, physical inactivity, and high rates of obesity -- as well as genetic tendencies in some populations -- largely drive the increasing global prevalence. The condition is also frequently diagnosed relatively late, once significant damage to vital organs has already taken place, further complicating treatment and management. Type 2 diabetes has a significant economic impact, imposing substantial burdens on individuals and healthcare systems. The financial burden of diabetes and its complications was estimated to exceed billions of dollars per year, with indirect costs (due to lost productivity) contributing to this financial burden. The global epidemic of type 2 diabetes (T2D) has become a priority target for population health activities because of its marked prevalence and associated morbidity and mortality, though the need for effective prevention and early detection, as well as comprehensive management of the condition is urgent. Combating this rising epidemic will require a combination of public health efforts, policy changes, education and technological innovations, including for artificial intelligence [5-7].

IV. Rising Prevalence and Public Health Challenge

Increasing Incidence of Type 2 Diabetes: The global rise in Type 2 diabetes is set to continue as a result of changing lifestyles, urbanization, and demographic shifts. Physical inactivity, unhealthy diets high in processed sugar and fats, and the worldwide obesity epidemic continue to be the major factors causing this epidemic. According to the International Diabetes Federation (IDF), the number of individuals affected by diabetes is expected to increase to 700 million by 2045. The rise is especially steep in countries with low or middle incomes, where economic growth has caused changes in diet and reduced physical activity. Aging populations are part of the surge, too, because the risk of Type 2 diabetes climbs as we age. It's not just an adult issue — the alarming rise in childhood obesity has resulted in an increase in Type 2 diabetes among young people, posing a big threat to future health systems.

Diabetes, a growing challenge for public health. Not only is this equality dependent on the fighting shapes of aging that are the leading cause of premature mortality, but also a major factor in driving up healthcare costs due to long-term complications, such as cardiovascular disease, kidney failure, blindness, and amputations. Especially in developing nations, health care systems are overwhelmed, and there has not been the infrastructure or numbers of resources to appropriately manage and run prevention protocols. Moreover, late diagnosis of Type 2 diabetes makes the matter worse because many people do not know they have the disease until it causes serious complications. Public health efforts struggle with the challenges of encouraging healthier habits, increasing access to preventive services, and improving early detection. Diabetes epidemic demands an integrated approach from education, public policy and applications of new technologies such as artificial intelligence for predict diagnostic and control [8-11].

V. Need for Early Detection and Limitations of Traditional Methods

Increasing Incidence of Type 2 Diabetes: Globally, Type 2 incidence is rapidly increasing due to lifestyle adjustments, urbanization, and demographic changes. The epidemic is driven primarily by sedentary lifestyles, unhealthy diets high in processed sugars and fats, and the global rise in obesity. According to the International Diabetes Federation (IDF), IDF estimates that 700 million people will be living with diabetes by the year 2045. The rise has been especially high in low- and middle-income countries, where economic growth has been accompanied by changes in diets and less active lifestyles. Another source of the uptick? Aging populations, since the risk of Type 2 diabetes increases with age. This growing prevalence is not only an adult problem, however, with preschool obesity rates reaching astonishing levels, and corresponding peaks of Type 2 diabetes incidence among these younger generations, a potential healthcare time bomb for tomorrow.

Global Health Concern: Investigator Initiated Studies (IIS) are essential, especially for worldwide health threats, such as the increasing burden of Type 2 diabetes on public health systems. Not just a primary cause of early death, you see this chronic disease accounts for one of the highest burdens on health costs, alongside all the long-term complications from this disease: heart disease, kidney failure, blindness, and also amputations. Unfortunately, healthcare systems, especially in underdeveloped countries, are currently overwhelmed to handle the influx as they stand to have limited availability of facilities and human resources for the management and prevention programs. In addition to this, Type 2 diabetes go undiagnosed for many people until it is too late: up to one in 12 have the disease without even knowing it. Public health efforts can have a formidable challenge in encouraging healthy living, and making sure preventive care is available and tested in the early phases. This calls for coordinated multi-stakeholder action, through education, public policy, to address this growing epidemic, and the harnessing of new technologies, such as artificial intelligence, to develop predictive diagnostics and personalized interventions [13].

VI. Role of Machine Learning (ML) and Artificial Intelligence (AI)

The Predictive Prowess of Machine Learning and AI: The use of machine learning (ML) and artificial intelligence (AI) is changing the landscape of how we predict Type 2 diabetes, offering more timely and accurate identification than conventional diagnostic techniques. ML and AI algorithms can analyze large datasets, which can include information from electronic health records (EHRs), wearable devices, and lifestyle assessments, to identify patterns, correlations, and risk factors which may be too complex for human cognition to detect. Such systems can assess hundreds of different variables at once, such as age, body mass index (BMI), blood glucose levels, family history, etc., and create individualized diabetes risk profiles in the process. This enables the recognition of individuals who are at high risk of developing diabetes long before the diagnosis of diabetes can be made by standard symptoms, thus targeting early intervention strategies (such as lifestyle change, pharmacologic treatment) to those at risk. AI can assist in the prediction of diabetes by refining the predictions on the basis of more accurate data, as update networks like neural models learn continuously.

Improving Healthcare Efficiency and Personalized Treatment: AI and ML contribute significantly to improving healthcare efficiency and personalizing treatments. For example, by synthesizing information from clinical data, family history, genetic or even environmental data, AI can create a more comprehensive picture of a patient's unique risk for diabetes. This allows for creating tailored treatment plans that better serve the patient, leading to improved outcomes and fewer complications. Furthermore, AI streamlines repetitive diagnostic processes, ensuring real-time oversight of patient metrics, lowering the burden on providers and facilitating prompt healthcare actions. AI systems can continuously analyze patient data so that they can detect subtle changes in a patient's condition, alerting providers to possible issues before they become serious problems. The models trained with digital data can help providers to proactively detect the risk of diseases and tackle them before they manifest, which improves the quality of care while addressing Type 2 diabetes & other chronic diseases through better long-term cost management [3-9] [14].

VII. Diverse Machine Learning Techniques in Diabetes Prediction

Machine learning (ML) techniques used in predicting Type 2 diabetes are diverse, ranging from traditional algorithms to more advanced deep learning models, each offering unique strengths depending on the complexity and nature of the data. Traditional algorithms like logistic regression are often the first choice for predicting diabetes due to their simplicity and interpretability. They provide clear insights into how each feature, such as age, body mass index (BMI), or blood glucose levels, contributes to the risk of developing diabetes. Decision trees and random forests are also widely used, as they handle non-linear relationships between variables and can capture interactions between multiple features. Random forests, in particular, are robust against overfitting and perform well on structured clinical data. Another popular method is the support vector machine (SVM), which excels at classifying complex datasets, particularly when combined with techniques like kernel tricks to handle non-linear data. On the more advanced end, gradient boosting machines (GBMs) such as XGBoost and LightGBM have gained prominence for their high accuracy and ability to handle large, complex datasets. These models are particularly powerful for diabetes prediction tasks because they iteratively improve performance by correcting errors made by previous models, yielding highly accurate risk assessments. For even deeper insights, neural networks and deep learning models, particularly those using multilayer perceptron's or recurrent neural networks (RNNs), are being applied to integrate diverse data sources, such as time-series data from glucose monitoring or even imaging data. Deep learning models excel at discovering intricate patterns in data that traditional methods might miss, though they require larger datasets and are less interpretable. As the complexity of the data increases, so does the need for advanced techniques, and ML offers a wide array of tools to predict diabetes risk with increasing precision and personalization also enhancement of big data security in cloud environment through this mechanism [2-5] [15].

VIII. Challenges and Ethical Considerations in AI for Healthcare

Data Privacy and Security: One of the primary challenges in using artificial intelligence (AI) in healthcare, particularly for predicting conditions like Type 2 diabetes, is ensuring data privacy and security. AI systems rely heavily on vast amounts of personal health data, including electronic health records (EHRs), genetic information, and data from wearable devices. This raises significant concerns about protecting sensitive patient information from breaches, unauthorized access, and misuse. Strict regulations such as HIPAA (Health Insurance Portability and Accountability Act) in the U.S. and GDPR (General Data Protection Regulation) in Europe mandate robust safeguards to protect patient privacy, but implementing these protections while still allowing AI systems to function effectively can be complex. Anonymizing data, ensuring secure data transfer, and maintaining transparency in data usage are all critical to maintaining trust in AI applications. Without strong data governance frameworks, patients and healthcare providers may be hesitant to fully embrace AI-driven healthcare solutions, which can hinder their potential benefits.

Bias and Fairness in AI Models: Bias in AI models is another critical ethical consideration, particularly in healthcare, where biased algorithms can lead to unequal treatment or misdiagnosis. AI systems trained on historical data that may reflect existing societal inequalities such as racial, gender, or socioeconomic disparities can unintentionally perpetuate these biases. For instance, if an AI model is primarily trained on data from a specific demographic group, its predictions may be less accurate for individuals from underrepresented populations, potentially leading to worse health outcomes for those groups. In diabetes prediction, this could mean that certain high-risk populations may not receive early warnings or interventions, exacerbating health disparities. Addressing bias requires careful attention to data selection, ensuring that datasets are diverse and representative of all patient groups. Additionally, developing explainable AI (XAI) models, where clinicians can understand how predictions are made, is crucial to ensuring that AI systems are fair, transparent, and equitable in their recommendations and decisions [12-15].

IX. Conclusion

Machine learning and artificial intelligence use in predicting Type 2 diabetes aims to address the increasing prevalence of the chronic disease and its complications. Advanced analytical techniques enable healthcare providers to identify at-risk individuals earlier and tailor interventions more effectively, which leads to better patient outcomes and reduces the burden on healthcare systems. Yet the successful adoption of AI technologies to healthcare practice comes with considerable challenges, including data privacy, data security, and concerns for algorithmic bias. It is important to create ai systems that track their AI models transparency, equity, and diversity as we start to build trust on these innovative models and gain from it. Modern research technology will improve the management of diabetes by artificial intelligence. As such, the involvement of technologists, healthcare professionals, and policymakers will be critical in ensuring this potential is upheld, along with ethical standards and the rights of patients.

References

1. Dagliati, A., Marini, S., Sacchi, L., Cogni, G., Teliti, M., Tibollo, V., ... & Bellazzi, R. (2018). Machine learning methods to predict diabetes complications. *Journal of diabetes science and technology*, *12*(2), 295-302.
2. Sarwar, M. A., Kamal, N., Hamid, W., & Shah, M. A. (2018, September). Prediction of diabetes using machine learning algorithms in healthcare. In *2018 24th international conference on automation and computing (ICAC)* (pp. 1-6). IEEE.

3. Padhy, S. K., Takkar, B., Chawla, R., & Kumar, A. (2019). Artificial intelligence in diabetic retinopathy: A natural step to the future. *Indian journal of ophthalmology*, *67*(7), 1004-1009.
4. Ting, D. S. W., Pasquale, L. R., Peng, L., Campbell, J. P., Lee, A. Y., Raman, R., ... & Wong, T. Y. (2019). Artificial intelligence and deep learning in ophthalmology. *British Journal of Ophthalmology*, *103*(2), 167-175.
5. Ellahham, S. (2020). Artificial intelligence: the future for diabetes care. *The American journal of medicine*, *133*(8), 895-900.
6. Wadhwa, S., & Babber, K. (2020). Artificial intelligence in health care: predictive analysis on diabetes using machine learning algorithms. In *Computational Science and Its Applications–ICCSA 2020: 20th International Conference, Cagliari, Italy, July 1–4, 2020, Proceedings, Part II 20* (pp. 354-366). Springer International Publishing.
7. Gautier, T., Ziegler, L. B., Gerber, M. S., Campos-Náñez, E., & Patek, S. D. (2021). Artificial intelligence and diabetes technology: a review. *Metabolism*, *124*, 154872.
8. Gong, J. N., Zhao, L., Chen, G., Chen, X., Chen, Z. D., & Chen, C. Y. C. (2021). A novel artificial intelligence protocol to investigate potential leads for diabetes mellitus. *Molecular Diversity*, *25*, 1375-1393.
9. Chaki, J., Ganesh, S. T., Cidham, S. K., & Theertan, S. A. (2022). Machine learning and artificial intelligence-based Diabetes Mellitus detection and self-management: A systematic review. *Journal of King Saud University-Computer and Information Sciences*, *34*(6), 3204-3225.
10. Ismail, L., Materwala, H., Tayefi, M., Ngo, P., & Karduck, A. P. (2022). Type 2 diabetes with artificial intelligence machine learning: methods and evaluation. *Archives of Computational Methods in Engineering*, *29*(1), 313-333.
11. Vehi, J., Mujahid, O., & Contreras, I. (2022). Artificial Intelligence and Machine Learning for Diabetes Decision Support. In *Advanced Bioscience and Biosystems for Detection and Management of Diabetes* (pp. 259-272). Cham: Springer International Publishing.
12. Jacobs, P. G., Herrero, P., Facchinetti, A., Vehi, J., Kovatchev, B., Breton, M., ... & Mosquera-Lopez, C. (2023). Artificial intelligence and machine learning for improving glycemic control in diabetes: best practices, pitfalls and opportunities. *IEEE reviews in biomedical engineering*.
13. Khaleel, F. A., & Al-Bakry, A. M. (2023). Diagnosis of diabetes using machine learning algorithms. *Materials Today: Proceedings*, *80*, 3200-3203.
14. Kamal, D., Sharma, A. K., & Kumar, D. (2022). Optimized ensembled model to predict drug toxicity using machine learning. *International Journal of Innovations in Engineering and Technology (IJIET)*, 22(4), 23–33. https://doi.org/10.21172/ijiet.224.03.
15. Shikha, & Kamal. (2020). Enhancement of big data security in cloud environment. *International Journal of Analytical and Experimental Modal Analysis*, XII (5), 1638–1645. https://doi.org/18.0002.IJAEMA.2020.V12I5.200001.0156740.